US008272204B2

(12) **United States Patent**
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(10) **Patent No.: US 8,272,204 B2**
(45) **Date of Patent: Sep. 25, 2012**

(54) **CORE COWL AIRFOIL FOR A GAS TURBINE ENGINE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 742 days.

(21) Appl. No.: **12/444,595**

(22) PCT Filed: **Oct. 12, 2006**

(86) PCT No.: **PCT/US2006/040247**

§ 371 (c)(1), (2), (4) Date: **Apr. 7, 2009**

(87) PCT Pub. No.: **WO2008/045089**

PCT Pub. Date: **Apr. 17, 2008**

(65) **Prior Publication Data**

US 2010/0077724 A1 Apr. 1, 2010

(51) **Int. Cl.**
F02K 3/02 (2006.01)

(52) **U.S. Cl.** **60/226.3**; 60/226.1; 60/226.2

(58) **Field of Classification Search** 60/226.1, 60/226.3, 232, 262, 771, 804, 226.2; 239/265.11, 239/265.19, 265.25

See application file for complete search history.

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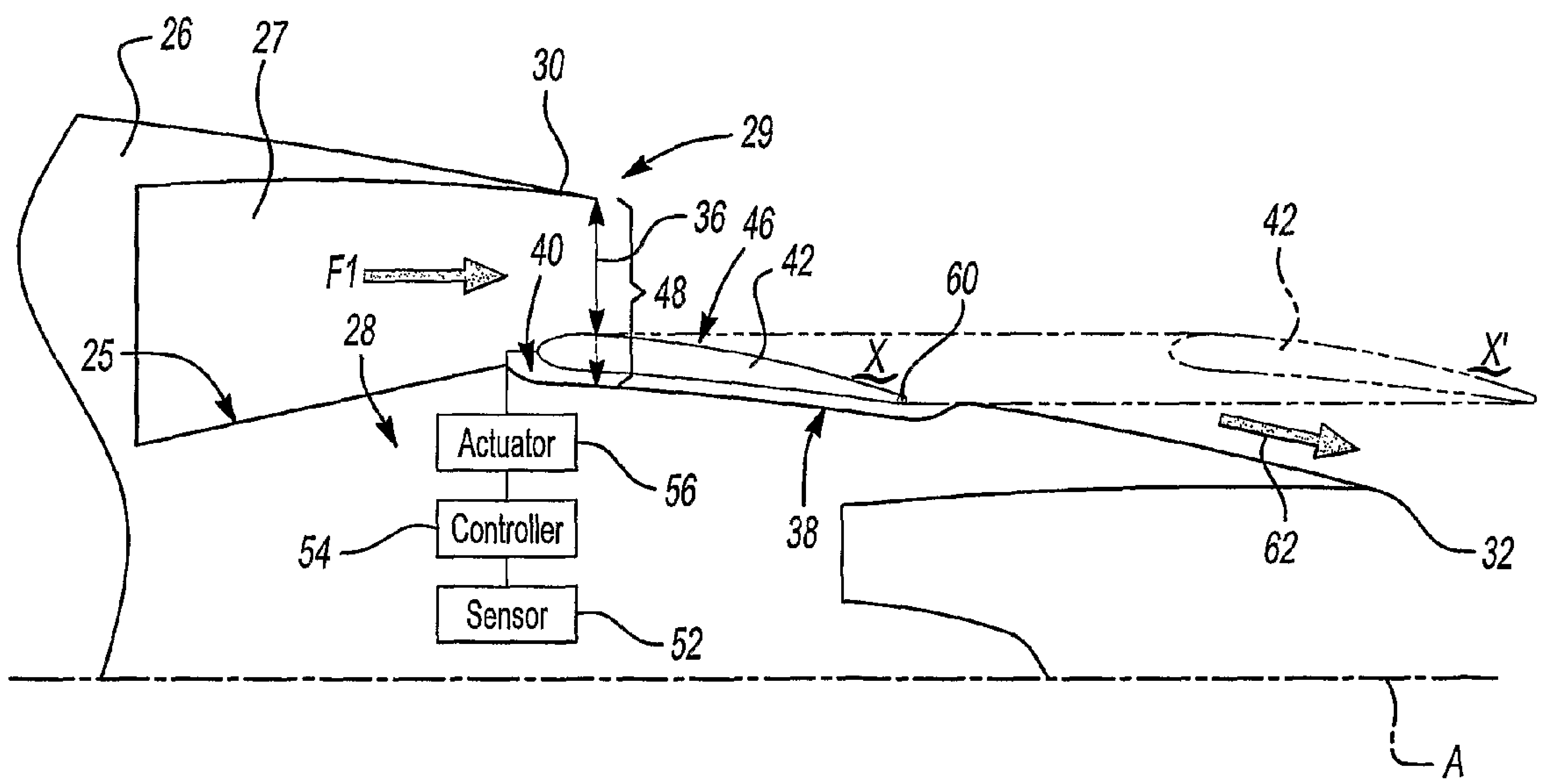
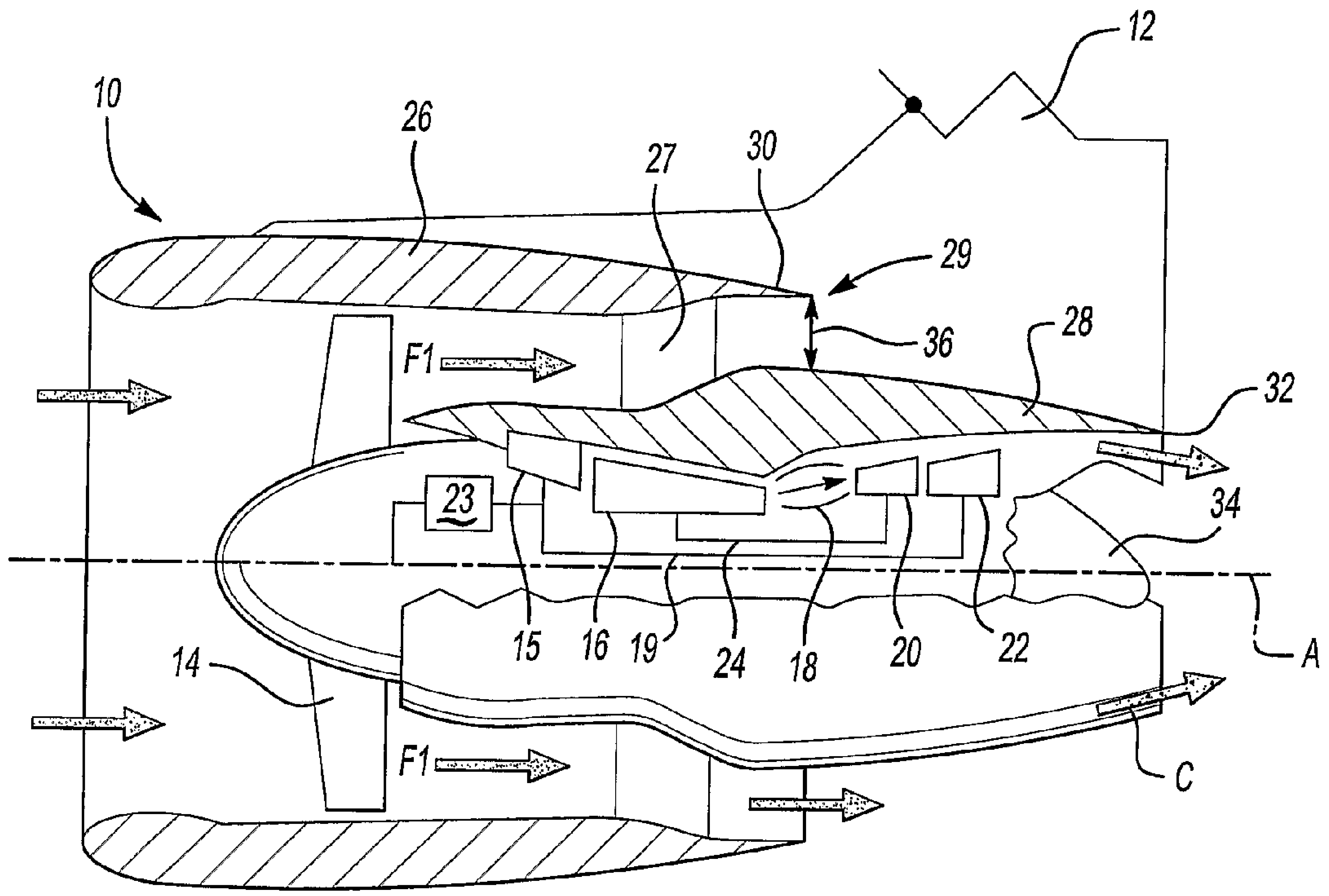
(57) **ABSTRACT**

An example core nacelle for a gas turbine engine includes a core cowl positioned adjacent an inner duct boundary of a fan bypass passage and having a pocket and an airfoil received within the pocket. The airfoil is moveable between a first position and a second position to adjust a discharge airflow cross-sectional area of the gas turbine engine.

16 Claims, 2 Drawing Sheets





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F1
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A
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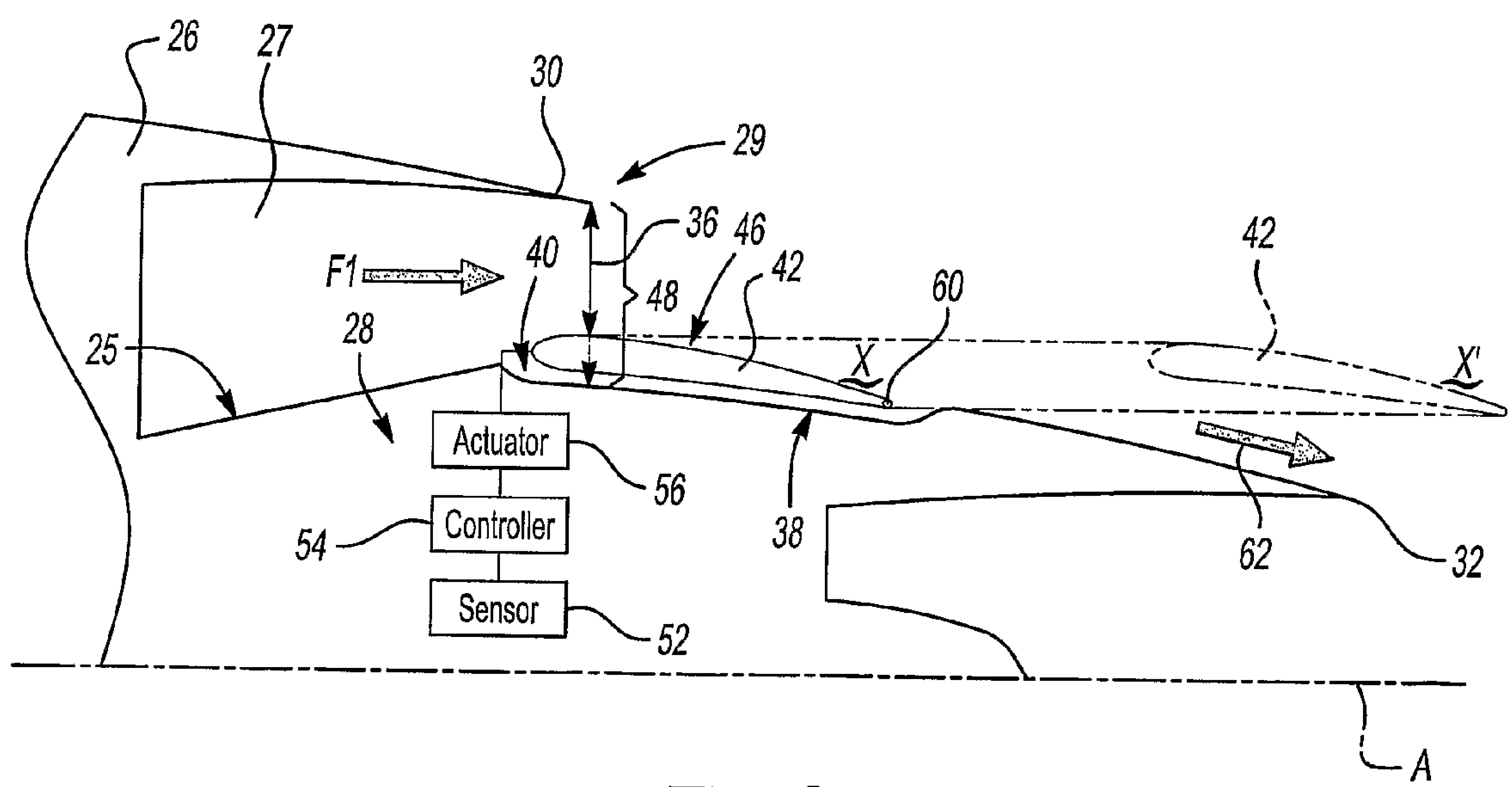
F1
C

Fig-1



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X'
25
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Actuator
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Sensor
52
A

Fig-2

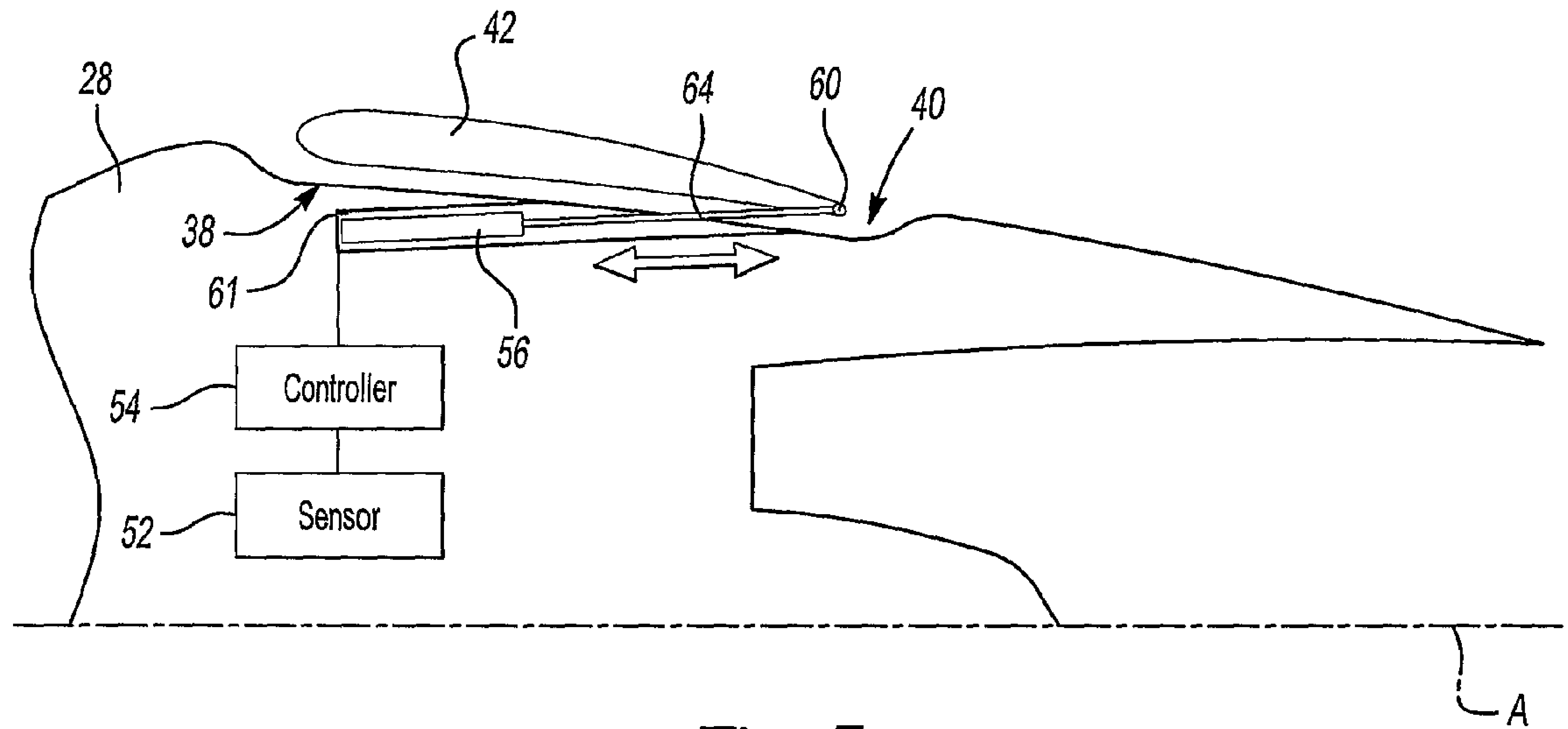
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Fig-3

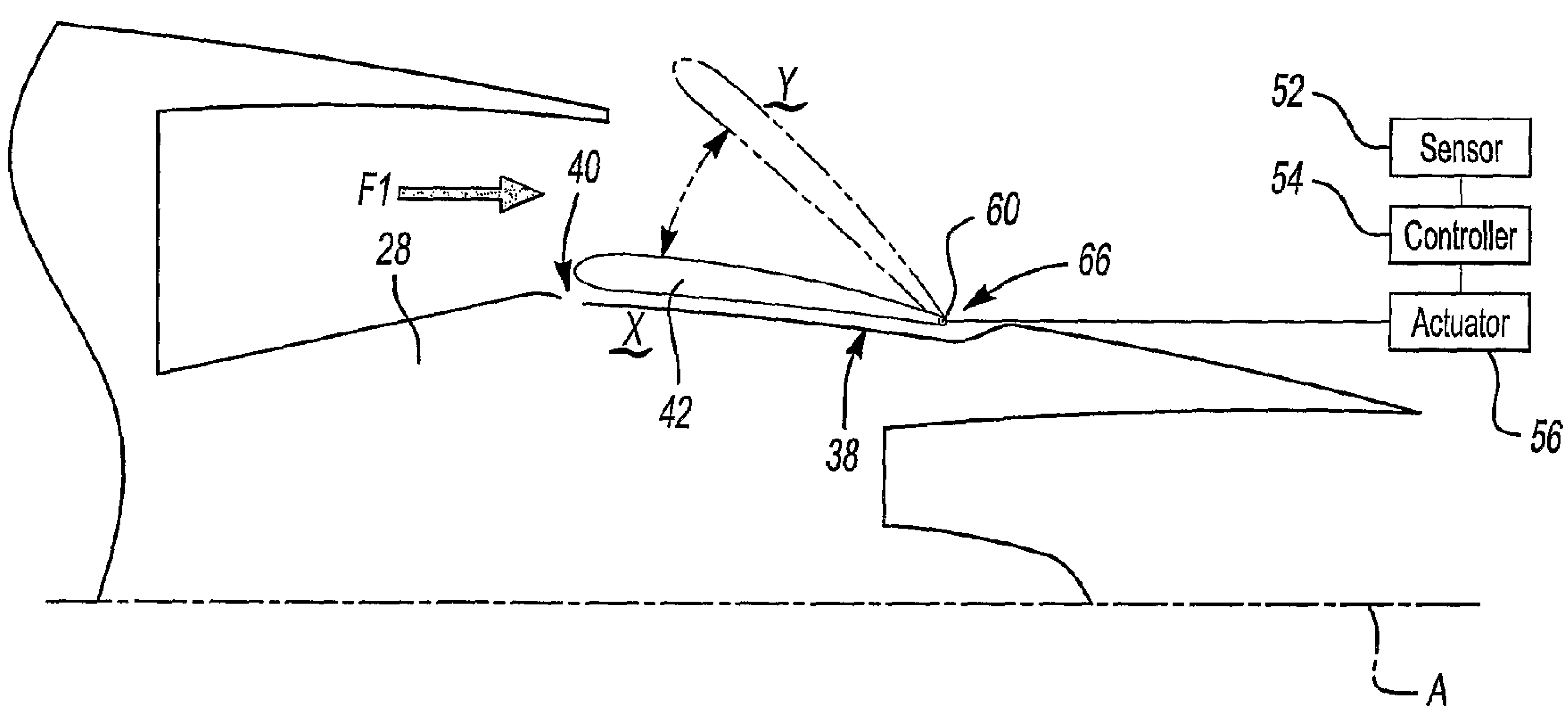
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Fig-4

CORE COWL AIRFOIL FOR A GAS TURBINE ENGINE

BACKGROUND OF THE INVENTION

This invention generally relates to a gas turbine engine, and more particularly to a turbofan gas turbine engine having a core cowl including an airfoil for increasing a discharge airflow cross-sectional area of the gas turbine engine.

In an aircraft gas turbine engine, such as a turbofan engine, air is pressurized in a compressor and mixed with fuel and burned in a combustor for generating hot combustion gases. The hot combustion gases flow downstream through turbine stages that extract energy from the gases. A high pressure turbine powers the compressor, while a low pressure turbine powers a fan disposed upstream of the compressor.

Combustion gases are discharged from the turbofan engine through a core exhaust nozzle, and fan air is discharged through an annular fan exhaust nozzle defined at least partially by a fan nacelle surrounding the core engine. A significant amount of propulsion thrust is provided by the pressurized fan air which is discharged through the fan exhaust nozzle. The combustion gases are discharged through the core exhaust nozzle to provide additional thrust.

A significant amount of the air pressurized by the fan bypasses the engine for generating propulsion thrust in turbofan engines. High bypass turbofans typically require large diameter fans to achieve adequate turbofan engine efficiency. Therefore, the nacelle of the turbofan engine must be large enough to support the large diameter fan of the turbofan engine. Disadvantageously, the relatively large size of the nacelle results in increased weight, noise and drag that may offset the propulsive efficiency achieved by the high bypass turbofan engine.

It is known in the field of aircraft gas turbine engines that the performance of the turbofan engine varies during diverse flight conditions experienced by the aircraft. Typical turbofan engines are designed to achieve maximum performance during normal cruise operation of the aircraft. Therefore, when combined with the necessity of a relatively large nacelle size, increased noise and decreased efficiency may be experienced by the aircraft at non-cruise operability conditions such as take-off, landing, cruise maneuver and the like.

Accordingly, it is desirable to provide a turbofan engine having a variable discharge airflow cross-sectional area that achieves noise reductions and improved fuel economy in a relatively inexpensive and non-complex manner.

SUMMARY OF THE INVENTION

An example core nacelle for a gas turbine engine includes a core cowl positioned adjacent an inner duct boundary of a fan bypass passage and having a pocket and an airfoil received within the pocket. The airfoil is moveable between a first position and a second position to adjust a discharge airflow cross-sectional area of the gas turbine engine.

An example nacelle assembly for a gas turbine engine includes a fan nacelle, a core nacelle within the fan nacelle that includes a core cowl having an airfoil, a sensor that detects an operability condition, and a controller in communication with the sensor to move the airfoil between a first position and a second position. The airfoil is received within a pocket of the core cowl and is positioned adjacent to a fan exhaust nozzle in the first position. The airfoil is moved to the second position to achieve a discharge airflow cross-sectional area greater than the discharge airflow cross-sectional area of the first position in response to detecting the operability condition.

An example method of increasing the discharge airflow cross-sectional area of a gas turbine engine includes sensing an operability condition and translating a core cowl airfoil in an aft direction of the gas turbine engine in response to detecting the operability condition. In one example, the operability condition includes a take-off condition.

The various features and advantages of this invention will become apparent to those skilled in the art from the following detailed description. The drawings that accompany the detailed description can be briefly described as follows.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a general perspective view of an example gas turbine engine;

FIG. **2** is a schematic view of an example gas turbine engine having a core cowl including an airfoil moveable between a first position and a second position;

FIG. **3** illustrates an example actuator assembly for moving the airfoil between the first position and the second position; and

FIG. **4** is a schematic view of an example gas turbine engine having a core cowl including an airfoil moveable between a first position and a third position that is different than the second position illustrated in FIG. **2**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **1**, a gas turbine engine **10** suspends from an engine pylon **12** as is typical of an aircraft designed for subsonic operation. In one example, the gas turbine engine is a geared turbofan aircraft engine. The gas turbine engine **10** includes a fan section **14**, a low pressure compressor **15**, a high pressure compressor **16**, a combustor **18**, a high pressure turbine **20** and a low pressure turbine **22**. A low speed shaft **19** rotationally supports the low pressure compressor **15** and the low pressure turbine **22** and drives the fan section **14** through a gear train **23**. A high speed shaft **24** rotationally supports the high pressure compressor **16** and a high pressure turbine **20**. The low speed shaft **19** and the high speed shaft **24** rotate about a longitudinal centerline axis A of the gas turbine engine **10**.

During operation, air is pressurized in the compressors **15**, **16** and mixed with fuel and burned in the combustor **18** for generating hot combustion gases. The hot combustion gases flow through the high and low pressure turbines **20**, **22** which extract energy from the hot combustion gases.

The example gas turbine engine **10** is in the form of a high bypass ratio (i.e., low fan pressure ratio geared) turbofan engine mounted within a fan nacelle **26**, in which most of the air pressurized by the fan section **14** bypasses the core engine itself for the generation of propulsion thrust. The example illustrated in FIG. **1** depicts a high bypass flow arrangement in which approximately **80** percent of the airflow entering the fan nacelle **26** may bypass the core nacelle **28** via a fan bypass passage **27**. The high bypass flow arrangement provides a significant amount of thrust for powering the aircraft.

In one example, the bypass ratio is greater than 10, and the fan section **14** diameter is substantially larger than the diameter of the low pressure compressor **15**. The low pressure turbine **22** has a pressure ratio that is greater than 5, in one example. The gear train **23** can be any known gear system, such as a planetary gear system with orbiting planet gears, planetary system with non-orbiting planet gears, or other type of gear system. In the disclosed example, the gear train **23** has a constant gear ratio. It should be understood, however, that the above parameters are only exemplary of a contemplated geared turbofan engine. That is, the invention is applicable to other engine architectures.

Fan discharge airflow F**1** is discharged from the engine **10** through a fan exhaust nozzle **30**, defined radially between a core nacelle **28** and the fan nacelle **26**. Core exhaust gases C are discharged from the core nacelle **28** through a core exhaust nozzle **32** defined between the core nacelle **28** and a tail cone **34** disposed coaxially therein around the longitudinal centerline axis A of the gas turbine engine **10**.

The fan exhaust nozzle **30** concentrically surrounds the core nacelle **28** near an aft most segment **29** of the fan nacelle **26**. The fan exhaust nozzle **30** defines a discharge airflow cross-sectional area **36** associated with the fan bypass passage **27** between the fan nacelle **26** and the core nacelle **28** for axially discharging the fan discharge airflow F**1** pressurized by the upstream fan section **14**.

FIG. **2** illustrates an example core cowl **38** of the core nacelle **28** of the gas turbine engine **10**. The core cowl **38** is an exterior flow surface of a section of the core nacelle **28**. The core cowl **38** is positioned adjacent an inner duct boundary **25** of the fan bypass passage **27**. The example core cowl **38** includes a pocket **40** for receiving an airfoil **42** near a top side of the core nacelle **28**. Although the pocket **40** and the airfoil **42** are illustrated at the top side of the core nacelle, it should be understood that additional locations of the core nacelle could have a similar configuration. In one example, the airfoil **42** is at least partially received within the pocket **40** adjacent to the fan exhaust nozzle **30**. The actual size and shape of the airfoil **42** and the pocket **40** of the core cowl **38** will vary depending upon design specific parameters including, but not limited to, the size of the core nacelle **28** and the efficiency requirements of the gas turbine engine **10**.

In the illustrated example, the discharge airflow cross-sectional area **36** extends within the fan bypass passage **27** between the aftmost segment **29** of the fan nacelle **26** adjacent the fan exhaust nozzle **30** and an upper surface **46** of the airfoil **42**. Varying the discharge airflow cross-sectional area **36** of the gas turbine engine **10** during specific flight conditions provides noise reductions and improved fuel consumption of the gas turbine engine **10**. In one example, the discharge airflow cross-sectional area **36** is varied by translating the airfoil **42** aft from its stored position within the pocket **40**. The airfoil **42** is moved from a first position X (i.e., the stored position within the pocket **40**, represented by solid lines) to a second position X' (represented by phantom lines) in response to detecting an operability condition of the gas turbine engine **10**. A discharge airflow cross-sectional area **48** of the second position X' is greater than the discharge airflow cross-sectional area **36** of the first position X. In one example, the operability condition includes a take-off condition. However, the airfoil **42** may be translated between the first position X and the second position X' in response to any known operability condition, such as landing or cruise.

A sensor **52** detects the operability condition and communicates with a controller **54** to translate the airfoil **42** between the first position X and the second position X' via an actuator assembly **56**. Of course, this view is highly schematic. It should be understood that the sensor **52** and the controller **54** are programmable to detect known flight conditions. A person of ordinary skill in the art having the benefit of the teachings herein would be able to program the controller **54** to communicate with the actuator assembly **56** to translate the airfoil **42** between the first position X and the second position X'. The distance the airfoil **42** translates in response to detecting the operability condition will vary depending on design specific parameters. The actuator assembly **56** moves the airfoil **42** from the second position X' to the first position X within the pocket **40** during normal cruise operation (e.g., a generally constant speed at generally constant, elevated altitude) of the aircraft.

A secondary airflow passage **62** in addition to the fan bypass passage **27** extends between the airfoil **42** and the core exhaust nozzle **32** when the airfoil **42** is positioned at the second position X'. The secondary airflow passage **62** provides an additional passage for fan airflow F**1** that in turn provides acoustic benefits. The secondary airflow passage **62** provides acoustic changes of the fan airflow F**1** through the fan bypass passage **27**.

The second discharge airflow cross-sectional area **48** permits an increased amount of fan airflow F**1** to exit the fan exhaust nozzle **30** as compared to the first discharge airflow cross-sectional area **36**. Therefore, the fan section **14** design is optimized for diverse operability conditions to achieve noise reductions and maximize fuel economy.

FIG. **3** illustrates an example actuator assembly **56** mounted within a cavity **61** of the core nacelle **28**, for example. In another example, the actuator assembly **56** is mounted to the core cowl **38**. The actuator assembly **56** extends the airfoil **42** between the first position X and the second position X' in response to detecting the operability condition. In one example, the actuator assembly **56** comprises a hydraulically extendable rod **64**. In another example, the actuator assembly **56** comprises an electrically extendable rod. In yet another example, the actuator assembly **56** is a ball screw. A worker of ordinary skill in the art with the benefit of the teachings herein would understand how to extend the airfoil **42** between the first position X and the second position X'. One example pocket **40** of the core cowl **38** is designed slightly larger than the airfoil **42** to provide clearance for the translation of the airfoil **42** between the first position X and the second position X'.

FIG. **4** illustrates another example arrangement of the airfoil **42**. The airfoil **42** is pivotally mounted within the pocket **40** of the core cowl **38** with a pivot mount **60**, for example. In one example, the pivot mount is a hinge pin. Other types of mounts may also be used to attach the airfoil **42** to the core cowl **38**. The pivot mount **60** is located near a trailing edge **66** of the airfoil **42**, in one example. However, the pivot mount **60** may be located anywhere on the airfoil **42**. A worker of ordinary skill in the art with the benefit of the teachings herein would be able to pivotally mount the airfoil **42** within the pocket **40**.

The airfoil **42** is pivotable between the first position X within the pocket **40** and another position Y (represented by phantom lines) by rotating the airfoil **42** about the pivot mount **60**. In one example, the position Y is different than the second position X'. The pocket **40** is designed and sized to provide clearance for the rotational movement of the airfoil **42** between the first position X and the position Y. A worker of ordinary skill in the art with the benefit of this disclosure would understand how to design the pocket **40** to allow rotational movement of the airfoil **42**.

Positioning the airfoil **42** at the position Y provides the gas turbine engine **10** with a thrust spoiling feature. In the position Y, the airfoil **42** temporarily diverts the fan airflow F**1** such that the fan airflow F**1** is blown in a forward direction to provide a thrust reversing force that acts against the forward travel of the aircraft, providing deceleration.

In one example, the airfoil **42** is pivoted to the position Y in response to an approach condition. An aircraft experiences approach conditions where descending toward a landing strip to land the aircraft. However, other operability conditions may be suitable for pivoting the airfoil **42** to position Y, or to any other positions.

The sensor **52** detects the approach condition and communicates with the controller **54** to pivot the airfoil **42** about the pivot mount **60** via the actuator **56**. In one example, the sensor **52** detects the approach condition in response to the opening of the aircraft landing gear. In another example, the approach condition is detected in response to sensing a predefined aircraft altitude. In yet another example, the approach condition is detected in response to sensing a predefined aircraft airspeed.

In position Y, the fan discharge airflow F**1** is forced in a forward direction rather than an aft direction of the gas turbine engine **10**. Therefore, the airfoil **42** provides a thrust spoiling feature in a relatively inexpensive and non-complex manner as compared to prior-art thrust reversers. The airfoil **42** is returned from position Y to the first position X within the pocket **40** where thrust spoiling is no longer required by the aircraft.

The foregoing description shall be interpreted as illustrative and not in any limiting sense. A worker of ordinary skill in the art would recognize that certain modifications would come within the scope of this invention. For that reason, the follow claims should be studied to determine the true scope and content of this invention.

What is claimed is:

1. A core nacelle for a gas turbine engine, comprising

a core cowl positioned adjacent an inner duct boundary of a fan bypass passage, wherein said core cowl includes at least one pocket and at least one airfoil at least partially received within said at least one pocket, said at least one airfoil selectively movable between a first position within said at least one pocket and a second position that is downstream from said first position to adjust a discharge airflow cross-sectional area associated with said fan bypass passage, wherein said fan bypass passage extends between said core nacelle and a fan nacelle and a secondary airflow passage extends between said at least one airfoil and a core exhaust nozzle where said at least one airfoil is positioned at said second position.

2. The core nacelle as recited in claim **1**, wherein the first position corresponds to a first discharge airflow cross-sectional area and the second position corresponds to a second discharge airflow cross-sectional area greater than said first discharge airflow cross-sectional area, wherein said at least one airfoil is selectively moved to said second position in response to at least one operability condition.

3. The core nacelle as recited in claim **2**, wherein said at least one operability condition includes a take-off condition.

4. The core nacelle as recited in claim **1**, comprising an actuator assembly operable to selectively translate said at least one airfoil between said first position and said second position.

5. The core nacelle as recited in claim **1**, wherein said at least one airfoil is pivotally attached to said core nacelle within said at least one pocket and is positioned adjacent to a fan exhaust nozzle.

6. The core nacelle as recited in claim **5**, comprising a pivot mount at a trailing edge of said at least one airfoil to pivotally attach said at least one airfoil to said core nacelle.

7. The core nacelle as recited in claim **1**, wherein said second position is aft of a fan exhaust nozzle associated with said fan bypass passage.

8. A gas turbine engine system, comprising:

a fan nacelle defined about an axis and having a fan exhaust nozzle adjacent an aftmost segment of said fan nacelle;

a core nacelle at least partially within said fan nacelle, said core nacelle having a core cowl positioned adjacent said fan exhaust nozzle, wherein said core cowl includes at least one pocket and at least one airfoil, said at least one airfoil at least partially received within said at least one pocket and moveable between a first position having a first discharge airflow cross-sectional area and a second position having a second discharge airflow cross-sectional area greater than said first discharge airflow cross-sectional area, wherein a fan bypass passage extends between said fan nacelle and said core nacelle and a secondary airflow passage extends between said at least one airfoil and a core exhaust nozzle when said at least one airfoil is positioned at said second position;

a fan section positioned within said fan nacelle;

a gear train that drives at least said fan section; at least one compressor and at least one turbine positioned downstream of said fan section;

at least one combustor positioned between said at least one compressor and said at least one turbine;

at least one sensor that produces a signal representing an operability condition; and

a controller that receives said signal, wherein said controller moves said at least one airfoil from said first position to said second position in response to said operability condition.

9. The system as recited in claim **8**, comprising an actuator assembly in communication with said controller and positioned within a cavity of said core nacelle, wherein said actuator assembly is extendable to selectively move said at least one airfoil between said first position and said second position in response to detecting said operability condition.

10. The system as recited in claim **8**, wherein said operability condition includes a take-off condition.

11. The system as recited in claim **8**, wherein said second position is aft of said first position.

12. The system as recited in claim **8**, comprising a pivot mount that pivotally mounts said at least one airfoil to said core nacelle, wherein said at least one airfoil is pivoted from said first position to a second position in response to detection of an approach condition, wherein said pivot mount is positioned near a trailing edge of said at least one airfoil.

13. A method of increasing a discharge fan airflow cross-sectional area of a gas turbine engine, comprising the steps of:

(a) sensing an operability condition; and

(b) translating a core cowl airfoil at least partially received within at least one pocket in an aft direction of the gas turbine engine to adjust the discharge fan airflow cross-sectional area in response to sensing the operability condition;

moving the core cowl airfoil from a first position to a second position, wherein the first position corresponds to a first discharge airflow cross-sectional area and the second position corresponds to a second discharge airflow cross-sectional area greater than the first discharge airflow cross-sectional area;

providing a secondary airflow passage that extends between the core cowl airfoil and a core exhaust nozzle in response to moving the said core cowl airfoil to the second position.

14. The method as recited in claim **13**, wherein the operability condition includes a take-off condition.

15. The method as recited in claim **13**, comprising the step of:

(c) returning the core cowl airfoil to the first position in response to detection of a cruise operation.

16. The method as recited in claim **15**, comprising the step of:

(d) pivoting the core cowl airfoil from the first position to a position different than the second position to spoil the thrust of the gas turbine engine in response to detection of an approach condition.

* * * * *